Measurement of Σ^+p elastic scattering cross sections at KEK-PS

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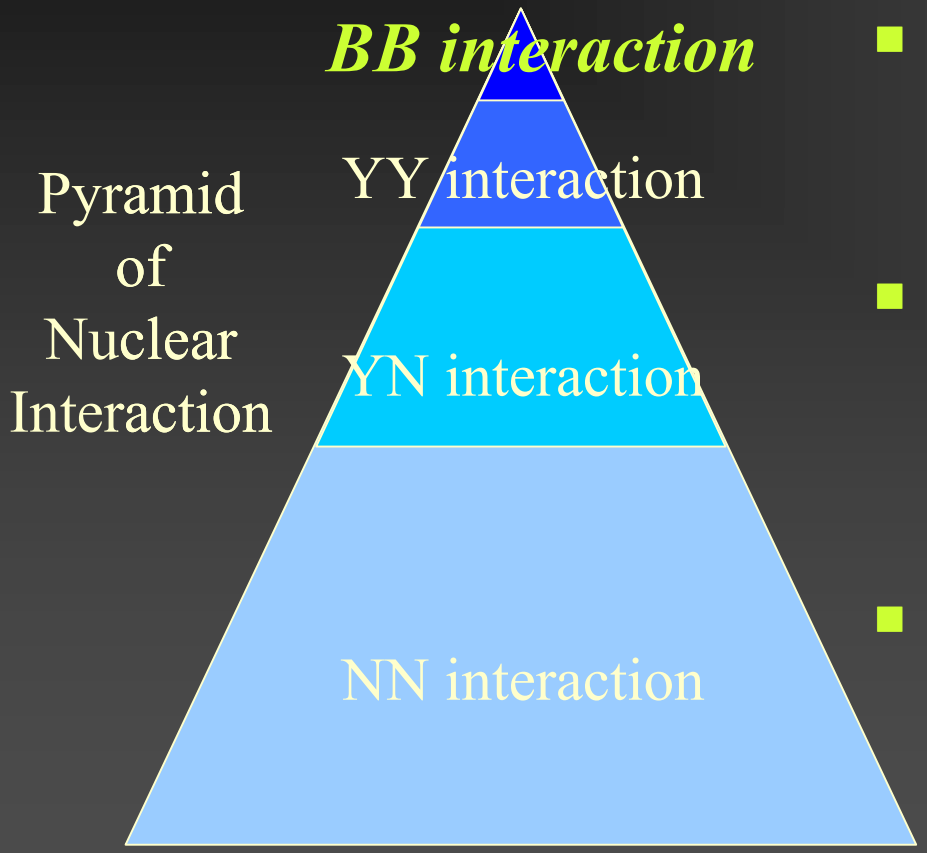
Outline

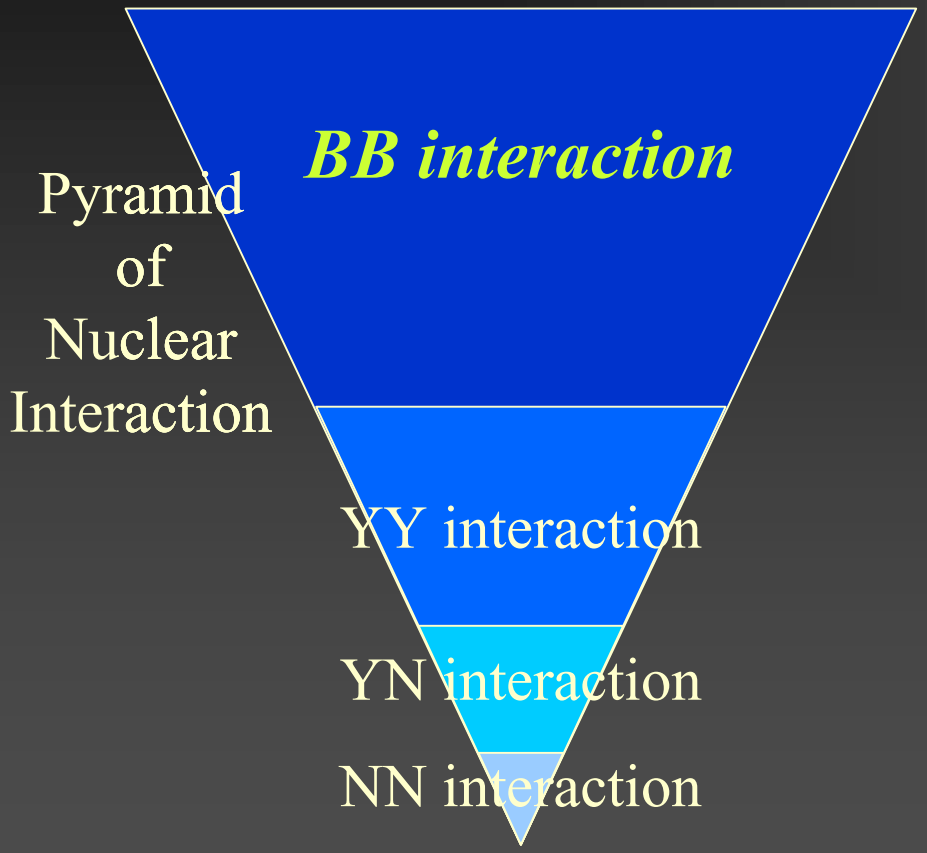
- Motivation
- Experimental Procedure
- Analysis
- Results
  - $d\sigma/d\Omega$
  - $\sigma(-0.8<\cos\theta_{CM}<0.8)$
  - Comparison with theoretical calculations
- Summary

Motivation



- YY interaction
  - Double-hypernuclear Structure (smaller statistics but interesting and important results)
- YN interaction
  - Scattering(bubble chamber, ***SCIFI***, SCITIC, small statistics, σ, $d\sigma/d\Omega$, Asymmetry),
  - Hypernuclear Structure
- NN interaction
  - Scattering(many method, good statistics,many observable…),
  - Nuclear Structure

Motivation



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Theories for describing the interactions between baryons

- Nijmegen Soft Core (NSC) models
  - Phenomenological soft core
  - One Boson Exchange potential (OBEP)
  - (Broken) flavor SU(3) symmetry
- Nijmegen Extended Soft Core models
  - The same feature with NSC
  - Uncorrelated two-meson exchange (TPS)
  - Meson-pair exchange (MPE)
- Kyoto-Niigata RGM-FSS, RGM-fss2
  - (3q) cluster for nucleon
  - Effective meson exchange potential (EMEP)
  - Spin-flavor SU(6) symmetry

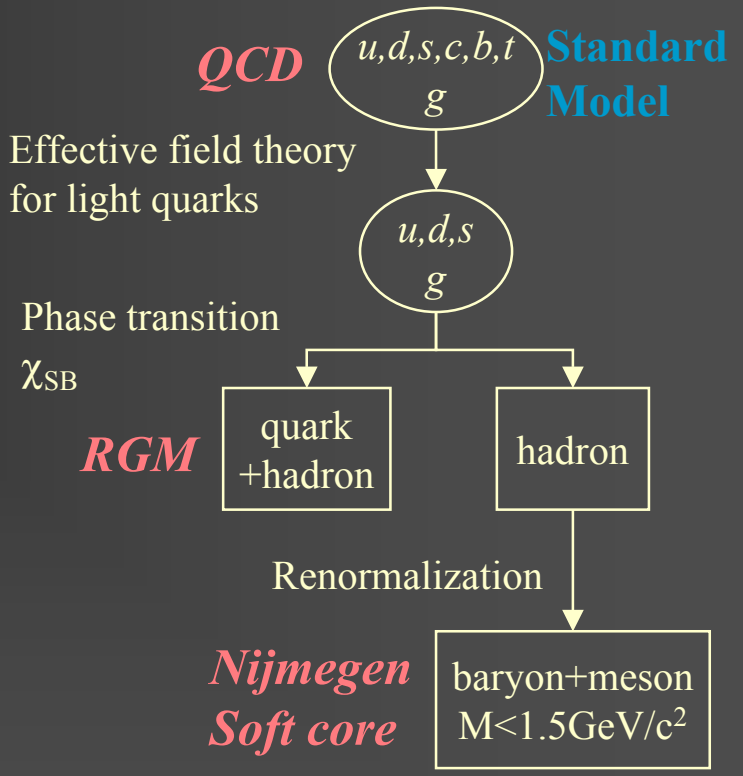
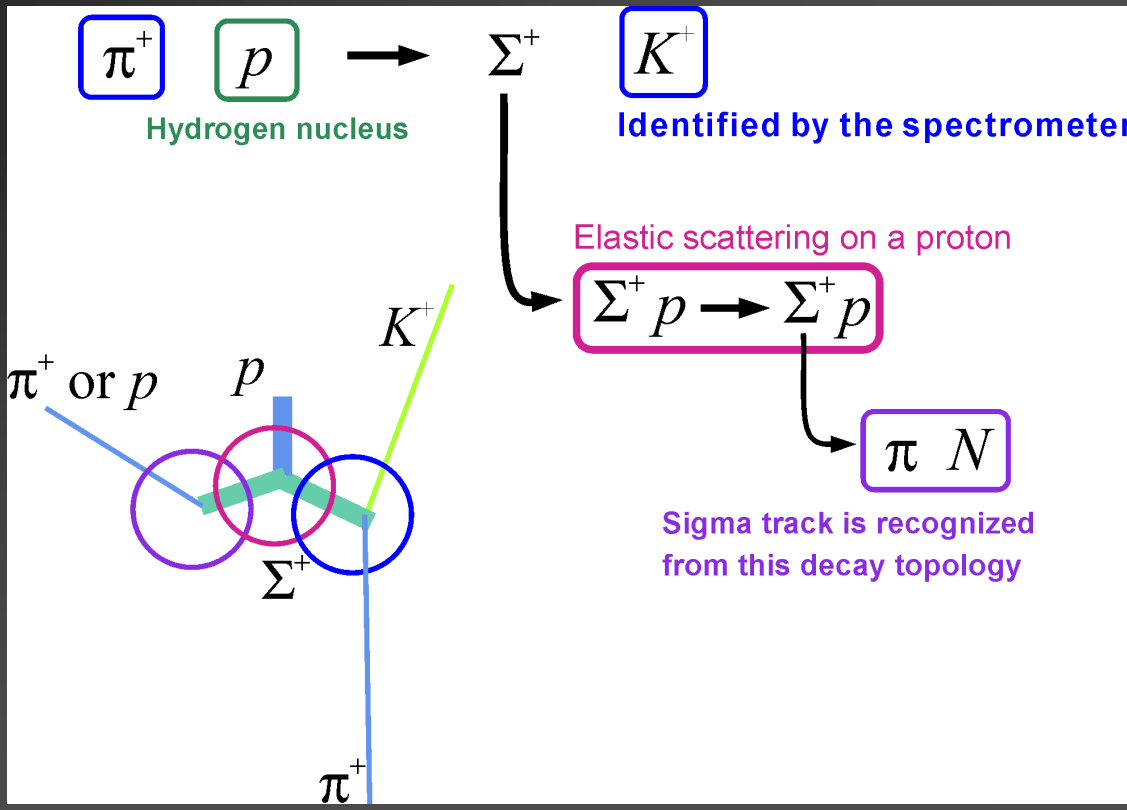


chart taken from
Polinder and Rijken nucl-th/0505083

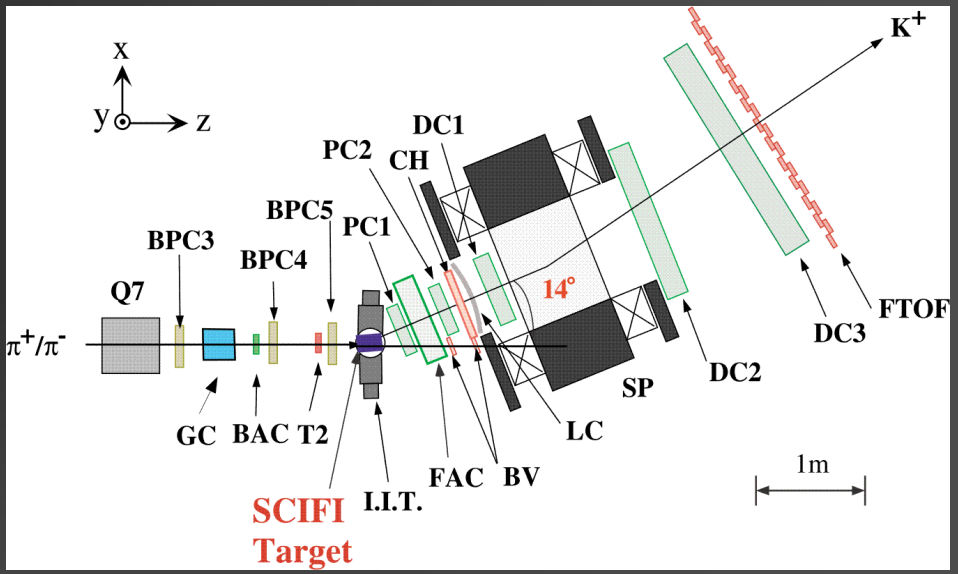
Experimental Procedure

- For tracking of the short tracks of hyperon and the recoil proton, an active target was developed.
- Track topology of all the charged particles relevant to the event was used to select hyperon production and scattering events.



Setup

- 1.64GeV/c π^+ beam
- Scintillating fiber active target (SCIFI) for proton target and particle tracking
- Magnetic spectrometer for K^+ detection and momentum analysis



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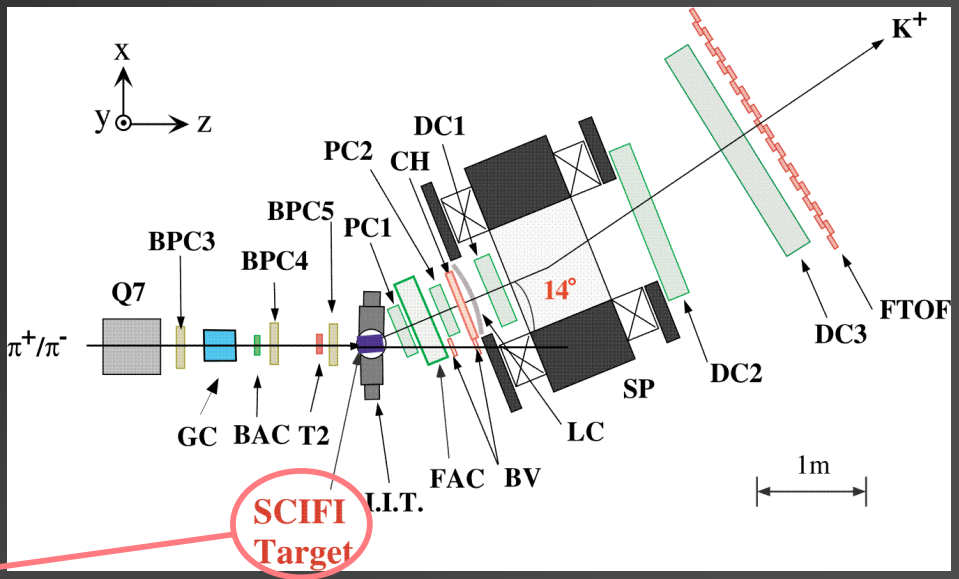

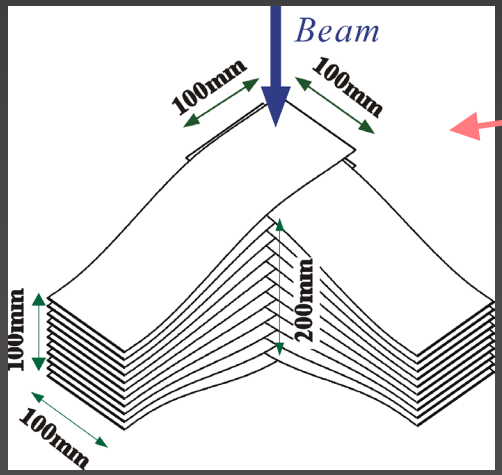

- Toray SCSF78 (0.3mm square cross section)
- Stacked perpendicular directions for three dimensional view
- Fiducial volume of 100mmX100mmX200mm

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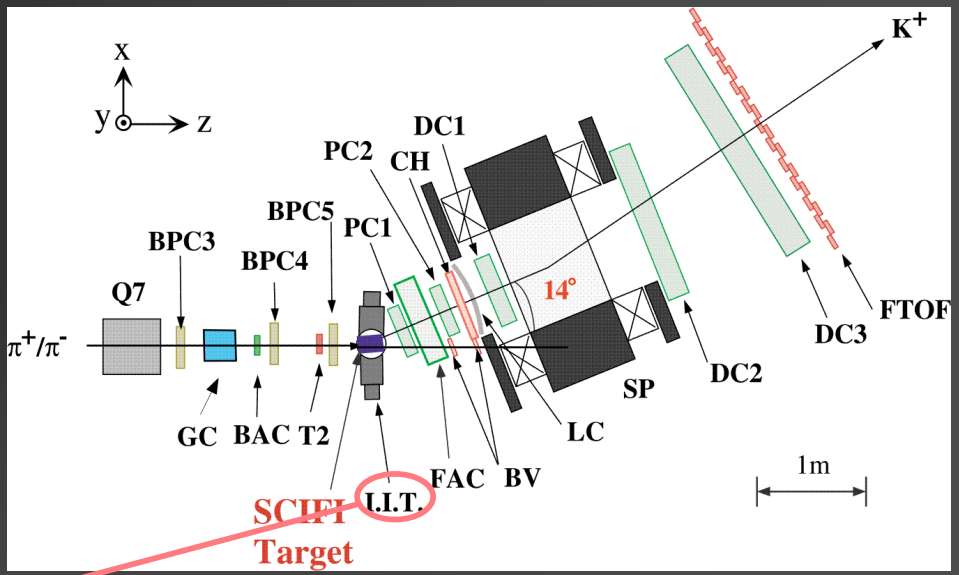
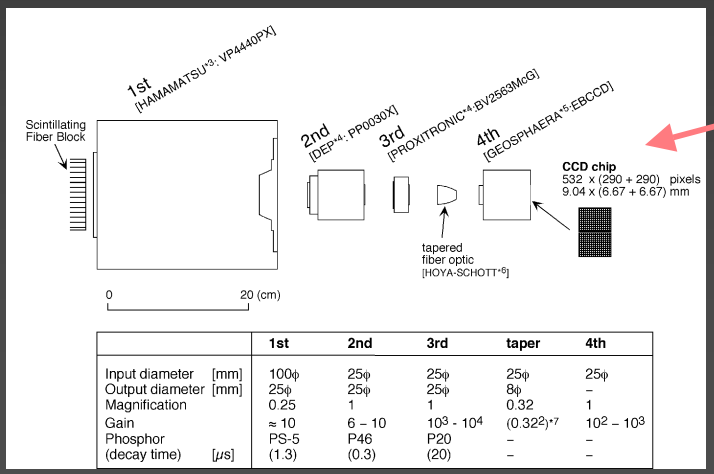


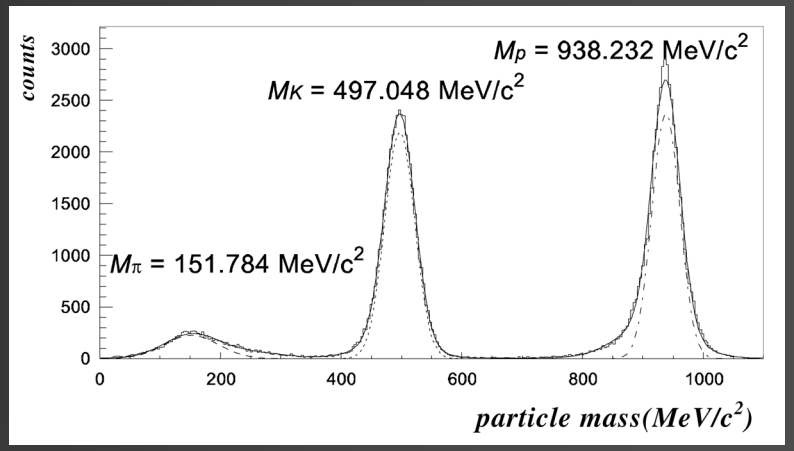


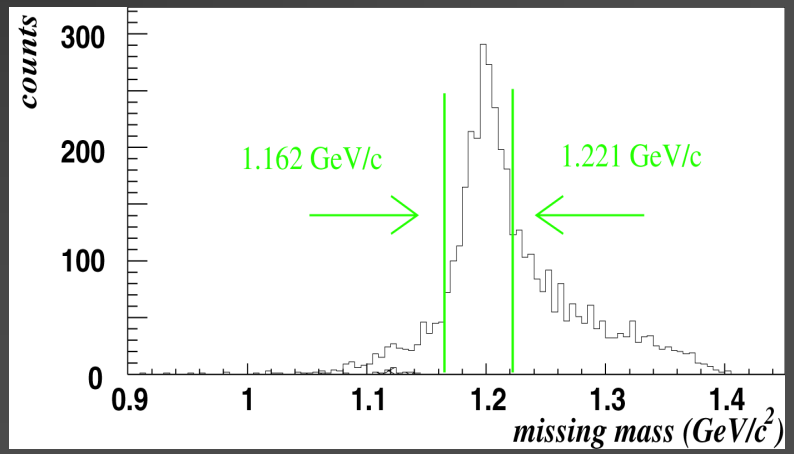
	1st	2nd	3rd	taper	4th
Input diameter [mm]	100φ	25φ	25φ	25φ	25φ
Output diameter [mm]	25φ	25φ	25φ	8φ	–
Magnification	0.25	1	1	0.32	1
Gain	≈ 10	6 – 10	10^3 - 10^4	(0.32^2)*7	10^2 – 10^3
Phosphor (decay time) [μs]	PS-5 (1.3)	P46 (0.3)	P20 (20)	–	–

- Three stage opt-electronics chain
- Electron bombarded CCD (EBCCD)
- Two sets of IIT's for three dimensional view

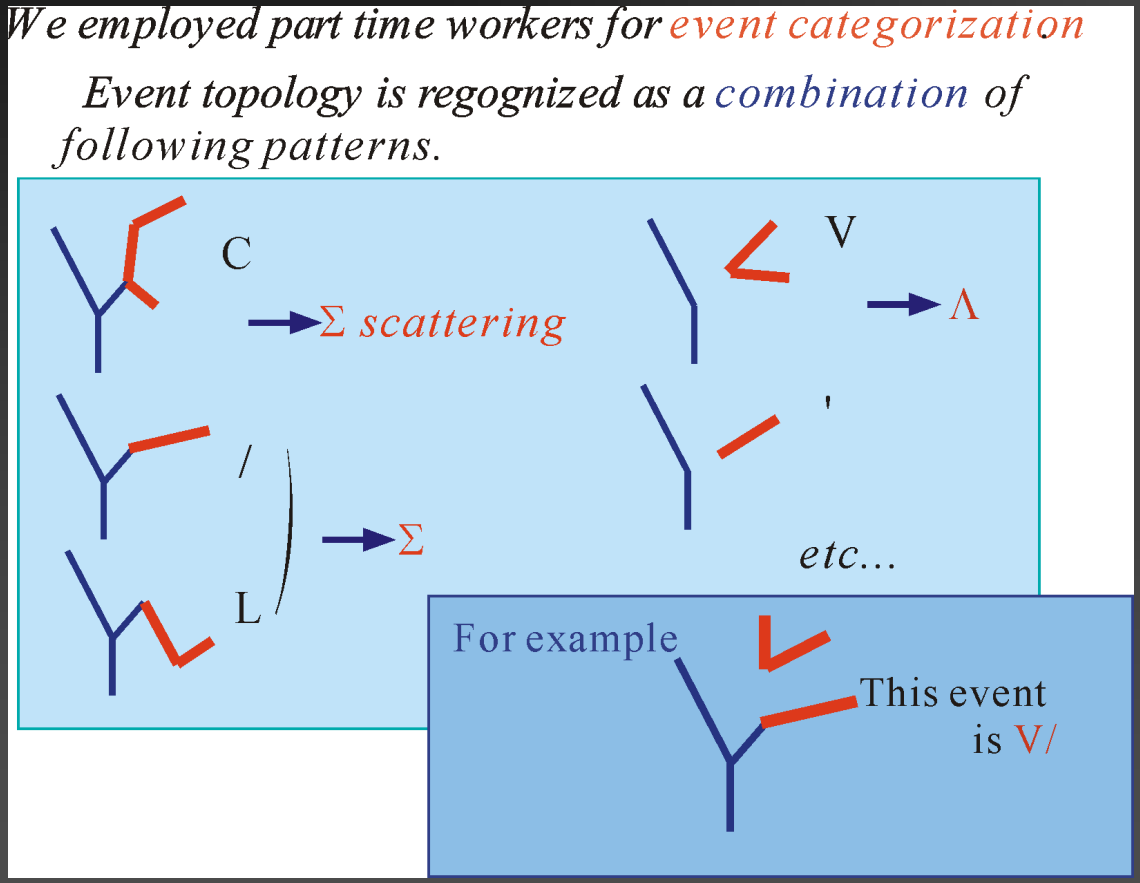
Spectrometer analysis

- 420 hours of data taking, 3.1×10^6 events were recorded.
- By the spectrometer analysis, 1.3×10^6 (π^+, K^+) events were identified.
- With missing mass cut, 0.68×10^6 events were eye-scanned (described in the next sheet).



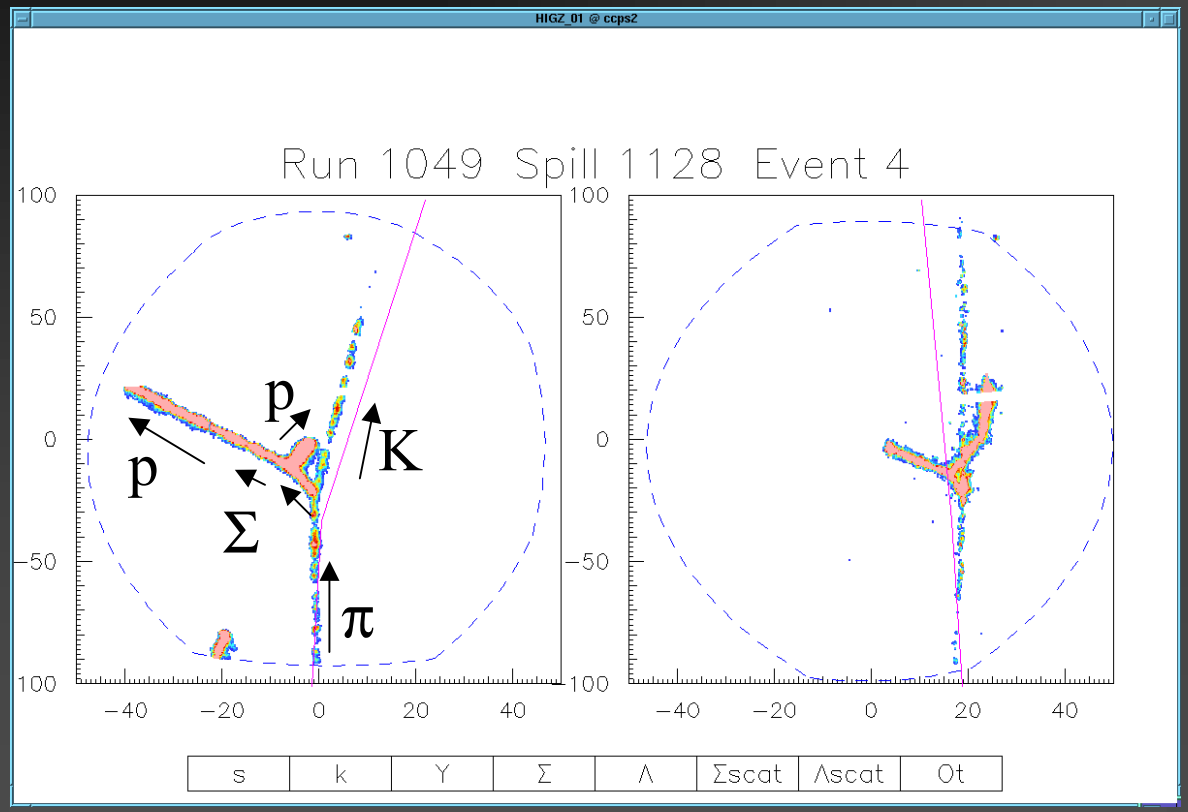


Eye-Scanning of image data



- Image data for events selected by the spectrometer analysis was scanned by human scanners.
- Simulated image data was merged in the images to be scanned by human scanners
  - Training of human scanners
  - Efficiencies for pattern recognition

Eye-Scanning of image data



Experimental data of a candidate for Σ^+p scattering

- Image data for events selected by the spectrometer analysis was scanned by human scanners.
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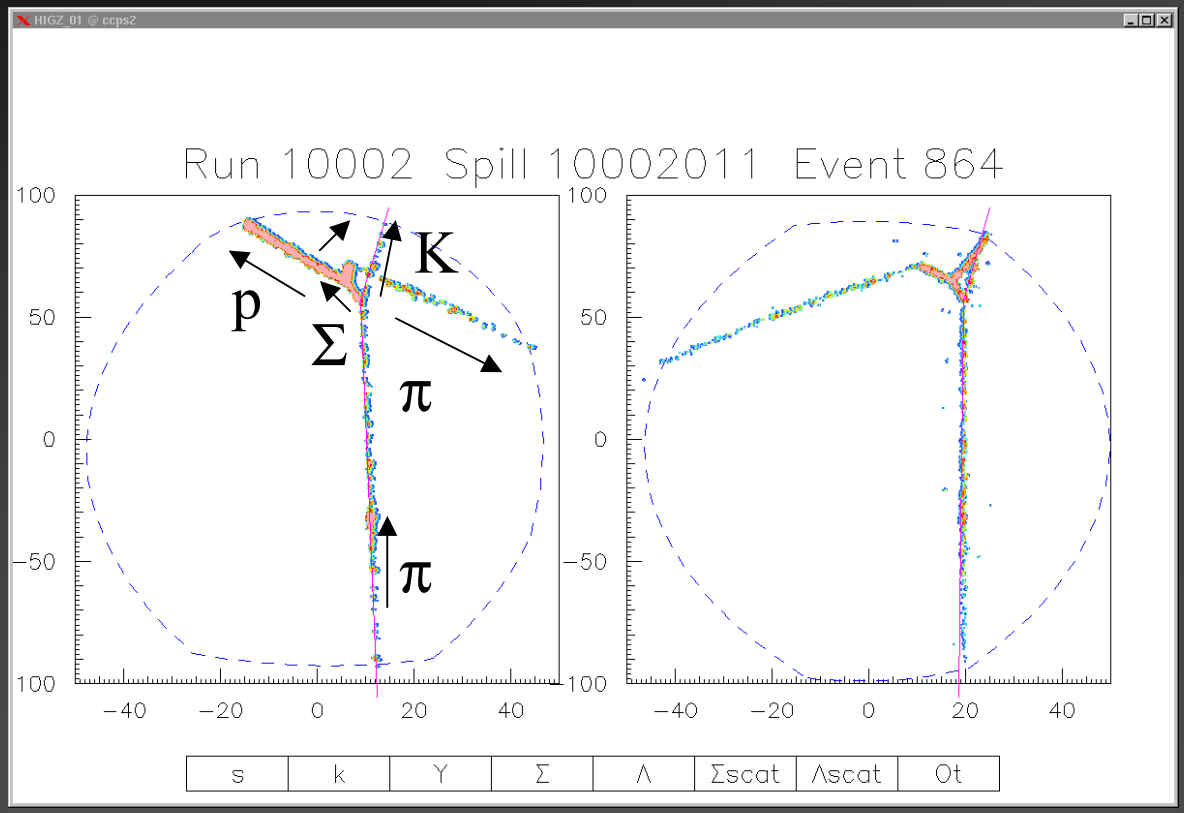
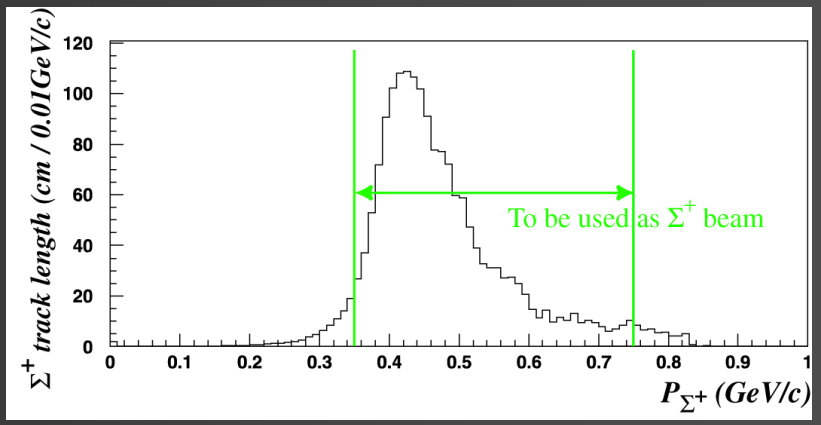


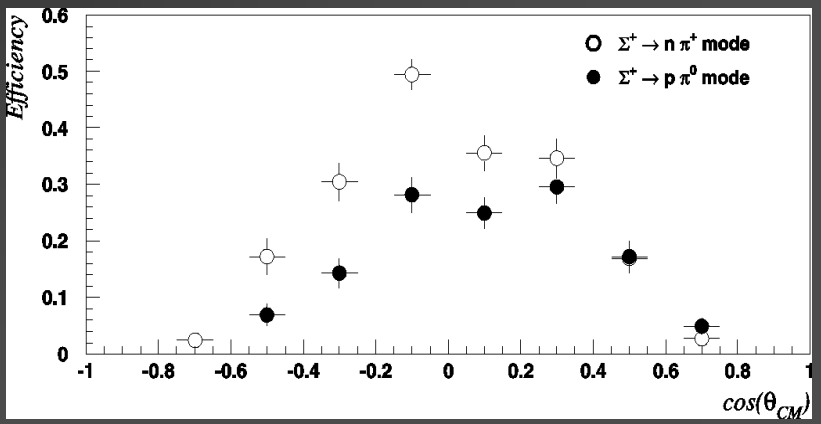
Simulation data for Σ^+p elastic scattering

- Image data for events selected by the spectrometer analysis was scanned by human scanners.
- Simulated image data was merged in the images to be scanned by human scanners
  - Training of human scanners
  - Efficiencies for pattern recognition

Track length, efficiency, background

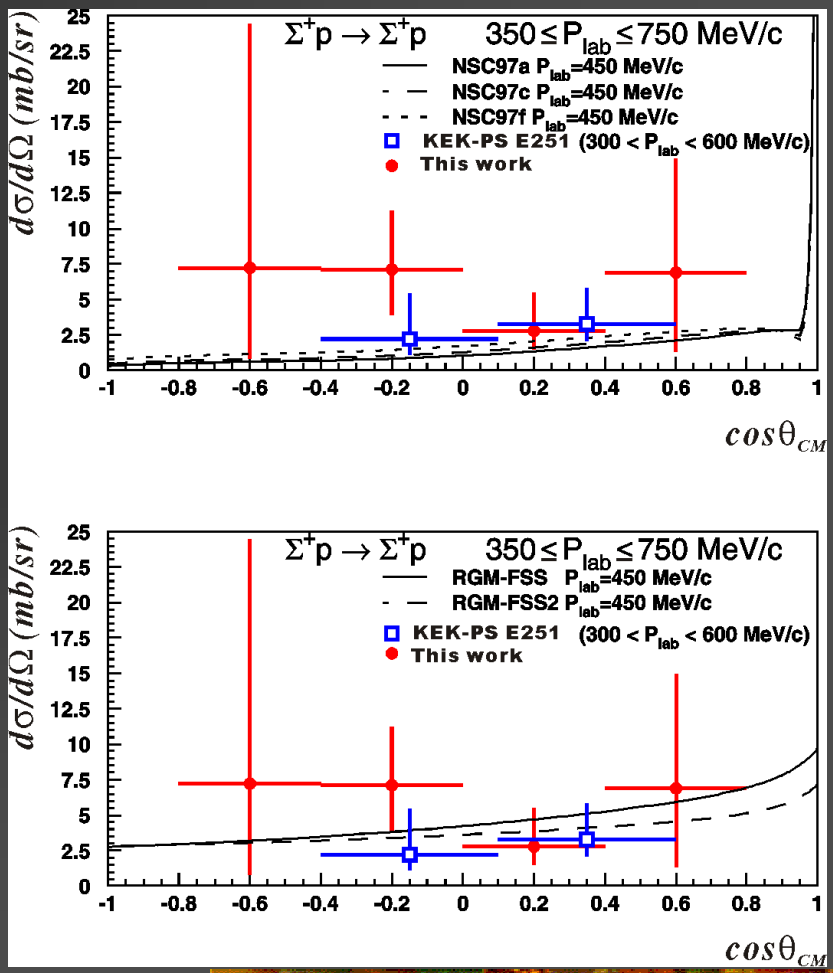
- From Σ^+ production candidates of 2.6×10^5 events, total track length of Σ^+ was estimated as $(5.01 \pm 0.04) \times 10^4$ cm. Its momentum ranges from 350 to 750 MeV/c with peak at around 450 MeV/c.
- Efficiencies and backgrounds were estimated by using simulation data.
  - Event finding efficiency of scanners
  - Analysis efficiency (kinematical and topological analysis)
  - Background due to Σ^+ scattering on quasi-free proton in C nucleus was estimated as 20.3+-10.3%.
- quasi-free scattering on deuteron or alpha particle was estimated from C(p, pd) and C(p, pα) cross sections -> smaller than C(p, 2p) cross section





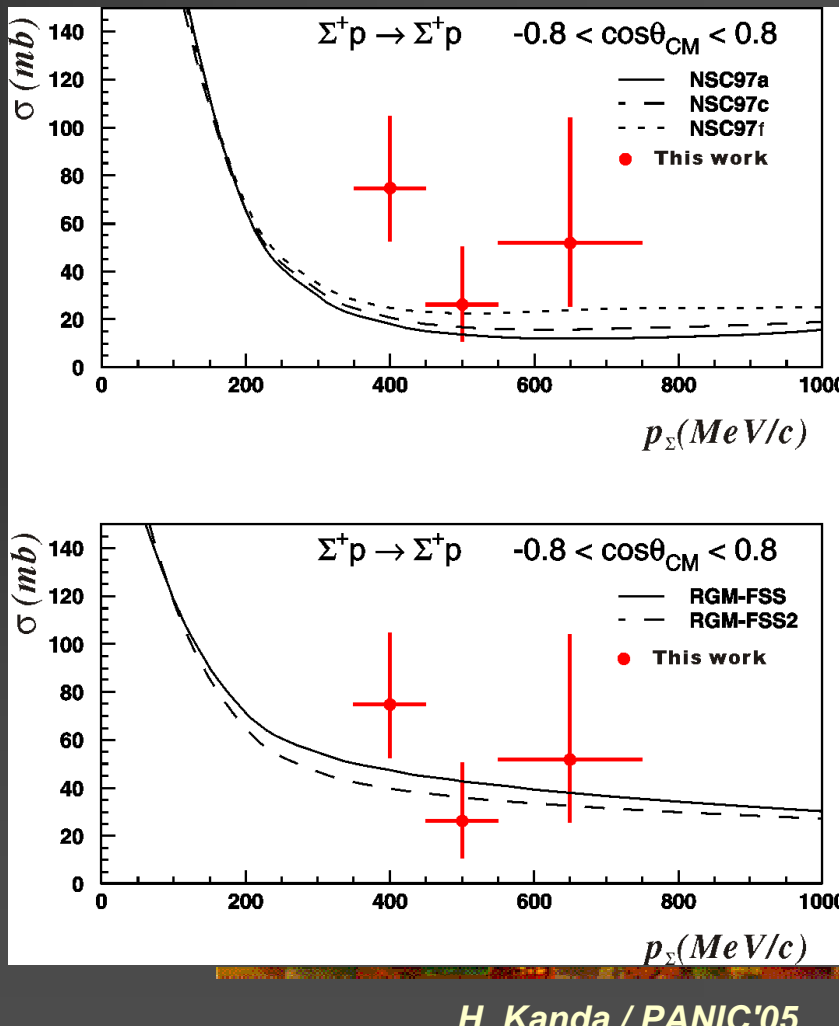
Differential cross section

- Out of Σ^+ scattering candidates of 9.4×10^3 events, 31 events survived the selection for $\Sigma^+ p$ elastic scattering.
- With use of track length, proton target density, efficiencies, and backgrounds differential cross sections were obtained.
- They agreed with the previous data from KEK-PS E251 within their errors.
- They were compared with the theoretical calculations by NSC97a, 97c, 97, RGM-FSS, and RGM-fss2 (in a single momentum of 450 MeV/c).



Cross section

- Momentum dependence of the cross sections was obtained in the angular range of $-0.8<\cos\theta_{CM}<0.8$.
- They were compared with the theoretical calculations by NSC97a, 97c, 97f, RGM-FSS, and RGM-fss2 ($d\sigma/d\Omega$ were integrated in the same angular range).
- They seem to agree with the RGM calculations.



Comparison with theoretical calculations

- The chi-squared analysis for theoretical calculations and experimental data
- The values of χ^2 and corresponding probabilities are summarized in the following table.
- Probability less than 0.05 is written in bold face.

	$\frac{d\sigma}{d\Omega}$ (this work)	$\frac{d\sigma}{d\Omega}$ (KEK-PS E251)	σ (this work)	$\frac{d\sigma}{d\Omega}$ and σ (this work)	All data points
Models	$N_{df}=4$	$N_{df}=2$	$N_{df}=3$	$N_{df}=7$	$N_{df}=9$
NSC97a	7(0.14)	3.5(0.17)	**9.3(0.026)**	**16.3(0.023)**	**19.8(0.019)**
NSC97c	6.1(0.19)	2.5(0.29)	**8(0.046)**	**14.1(0.049)**	16.6(0.055)
NSC97f	4.9(0.30)	1.1(0.58)	6.2(0.10)	11.1(0.13)	12.2(0.20)
RGM-FSS	2(0.74)	0.8(0.67)	2.2(0.3)	4.2(0.76)	5(0.83)
RGM-fss2	2.1(0.72)	1.1(0.58)	3.1(0.38)	5.2(0.64)	6.3(0.71)

Summary

- Σ^+p scattering experiment, KEK-PS E289 had been performed at the KEK-PS K2 beam line.
- Out of one million (π^+,K^+) events, 31 Σ^+p elastic scattering events have been found in the momentum region of $350<p_\Sigma<750$MeV/c and the angular region of $-0.8<\cos\theta_{CM}<0.8$.
- Differential cross sections and the integrated cross sections were obtained from these events.
- The differential cross sections were consistent with the previous data from KEK-PS E251 experiment within the error.
- The differential cross sections and the integrated cross sections were compared with the theoretical calculations by T. A. Rijken (NSC97a, 97c, 97f) and K. Fujiwara (RGM-FSS, RGM-fss2). By the chi-squared analysis, NSC97a can be rejected with confidence level of 95%.